COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

EPT.
954

COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

Vol. 3, No. 7 September, 1954

Publisher: Edmund C. Berkeley and Associates
36 West 11 St., New York 11, N.Y. — ALgonquin 4-7675
815 Washington St., Newtonville 60, Mass. — DEcatur 2-5453 or 3928

Effective September 1, 1954, COMPUTERS AND AUTOMATION is published twelve times a year monthly. Subscription rates: $4.50 for one year, $8.50 for two years, in the United States; $5.00 for one year, $9.50 for two years, in Canada; $5.50 for one year, $10.50 for two years elsewhere. Advertising rates: see page 36. Entered as second class matter at the Post Office, New York, N.Y.

THE EDITOR'S NOTES

Meetings. The fourth annual "Eastern Joint Computer Conference and Exhibition" will be held in the Bellevue-Stratford Hotel, Philadelphia, Pa., December 8 to 10, 1954 (Wednesday to Friday). The conference is jointly sponsored by the Association for Computing Machinery, the Institute of Radio Engineers, and the American Institute of Electrical Engineers. The theme of the conference will be "The Design and Application of Small Digital Computers". Over sixty companies will have exhibits at the conference. Proceedings of the conference will be published by the sponsoring societies and may be ordered from any of them. Information on registration, which is open to all, may be obtained by writing Eastern Joint Computer Conference, P.O. Box 7825, Philadelphia 1, Pa.

The "First International Automation Exposition" will be held at the 244th Regiment Armory, 120 West 14 St., New York, N.Y., November 29 to December 2, 1954 (Monday to Thursday). Advance registration is required and may be requested from Mr. Richard Rimbach, "Instruments and Automation", 845 Ridge Ave., Pittsburgh 12, Pa. It will contain an "Electronic Computer Clinic", at which lectures will be given by not more than nine computer manufacturers.

The "Automatic Control Equipment Exhibition" will be held at the Waldorf Astoria Hotel, New York, November 21-22 (Sunday and Monday). For more information, write to "Automatic Control", Reinhold Publishing Co., 430 Park Ave., New York, N.Y.

Roster of Magazines. Another piece of reference information which we have begun to publish starting with this issue is the "Roster of Magazines Related to Computers and Automation". With the advent of five now ones in 1954, it seems that it would be a help to our readers to give a factual report from time to time about them. We shall as usual be grateful for any additions or corrections that anyone is able to send us.

A New Type of Article. To our surprise we found in our mail the other day an unusual release from the news department of a large company. The release was thoroughly interesting, full of detail, well-written, not technical, and contained thought-provoking ideas. If it had come from an individual author, we would have accepted it as a good article, even if it did (perhaps justifiably) express a good deal of pride in the achievements of one company. So we have included it in this issue of "Computers and Automation" as an article.

We hope we shall find some more good articles of this new type.

Technical Papers. We have thought a good deal about opening the pages of "Computers and Automation" to papers, We have received several requests to do so. We know that some 110 papers were given at the meeting of the Association for Computing Machinery at Ann Arbor, Mich., in June, and that their journal can at most publish only 30 or 40 papers a year. What about the remaining papers?

We do not however plan to pay for papers, though we do for articles. What therefore is the difference between a paper and an article? An article appeals to a large audience; a paper, a small one. An article is not very technical; a paper is definitely technical. An article assumes a fairly small amount of prior knowledge; a paper assumes a large amount. An article defines any terms which most readers may not understand; a paper assumes that nearly all the readers it has will understand nearly all the terms it uses. An article contains a very small amount of mathematics and diagrams, if any; a paper may well include and assume a good deal of mathematics, a good many diagrams, etc. In most cases, we believe the distinction will be easy to agree about; and in any borderline case, the manuscript may be returned to the author to be modified to become one or the other.

Monthly Twelve Times a Year. With this issue, "Computers and Automation" goes from publication ten times a year to publication twelve times a year. The months of June and August will no longer be omitted. There will be no change in the subscription rate at this time.

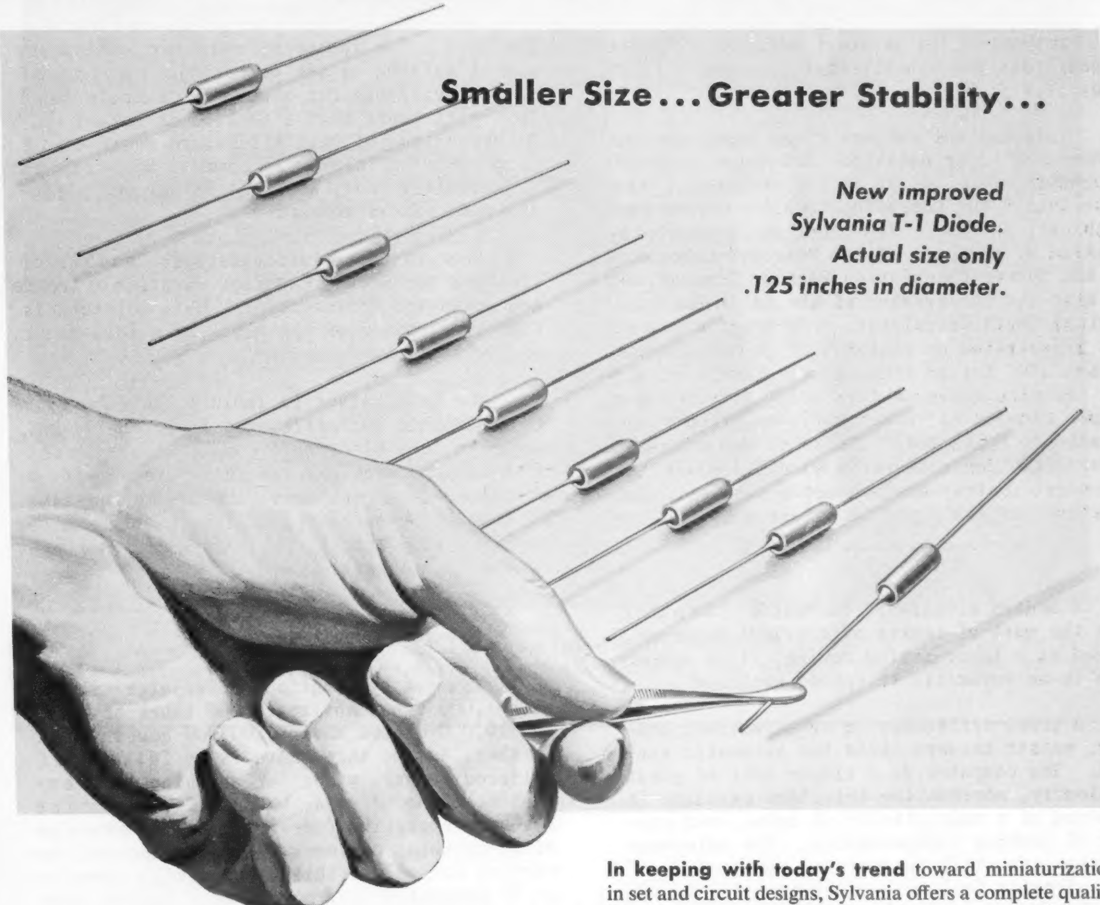
Address Changes. If your address changes, please notify us giving both old and new addresses, and allow three weeks for the change.

Back Copies. See the information on page 34.

Manuscripts. See the information on page 10.

Sylvania Offers You . . .

A NEW COMPACT DIODE LINE



In keeping with today's trend toward miniaturization in set and circuit designs, Sylvania offers a complete quality line of compact crystal diodes with improved stability.

These new components measure only .125 inches in diameter . . . require only 1/6th the space of former units. At the same time, due to advanced manufacturing techniques and Sylvania's new automatic precision equipment, they provide far higher performance records.

With these tiny diodes, you can be assured of more uniform characteristics and closer tolerance limits . . . even on large quantity orders.

This new T-1 Series also has recently passed MIL-E-1B moisture-resistance tests. Now available in capacities for every need. For full details write to Dept. 4E-1107, Sylvania today!

Another reason why it pays to specify Sylvania!

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

In Canada: Sylvania Electric (Canada) Ltd.
University Tower Building, St. Catherine Street, Montreal, P. Q.

LIGHTING · RADIO · ELECTRONICS · TELEVISION

COMPUTER FAILURES – AUTOMATIC INTERNAL DIAGNOSIS (AID)

Neil Macdonald
New York

How would you go about having a computer itself tell you exactly what is wrong with it when it fails?

This was the subject of an important and remarkable paper entitled "Automatic Internal Diagnosis (AID)" given at the meeting of the Association for Computing Machinery in Ann Arbor, Michigan, in June. The paper was presented by William H. Burkhart of the Monrobot Laboratory of the Monroe Calculating Machine Company, who is also the co-inventor of the Kalin-Burkhart Logical Truth Calculator. Burkhart's paper was illustrated by pictures of an actual model of an "AID" for an ordinary electronic counter, the electronic counter being selected as a simple example of an automatic electronic apparatus to be tested. The model was constructed in order to demonstrate in actual hardware the practical reality of Burkhart's concepts. The substance of his paper is reported below.

A modern electronic automatic computer does the work of scores of clerical employees. Viewed as a labor-saving device, it is comparable to an automatic telephone exchange.

A great difference in organization, however, exists between these two automatic systems. The computer is a single unit of great complexity, whereas the telephone exchange is composed of a multiplicity of units, each capable of working independently. The telephone exchange can still be operated successfully if some circuits fail -- by disconnecting the malfunctioning circuits; but the entire computer is rendered useless if one tube fails. It is as though all the automatic clerks have staged a walk-out -- until the single source of trouble is located and corrected.

Sudden machine collapse in this fashion may be extremely inconvenient where a computer is at work on an entire accounting problem. Under these conditions, "down-time" is important to avoid. Hence, it is worthwhile to examine the relation between computer inefficiency and its two contributing factors: failures of components and speed of repair.

Computer Efficiency

The literature on electronic calculators yields some interesting data on computer efficiency. For instance, computer efficiency may be defined as the percentage ratio of "hours available for error-free calculation" to "total hours that a machine is turned on." An evaluation of this literature shows that 75 percent efficiency is common, 85 percent is unusually good, and that 95 percent efficiency is almost unheard-of.

What is the relation between "number of troubles per week", "average duration of trouble", and "computer efficiency"? This relation is shown in Table 1 on the basis of a full week of 168 hours.

The information in Table 1, together with the fact that 85% efficiency is unusually good, suggests that electronic computers are beset with serious problems. If there are very few troubles, then each must take a very long time to locate. Conversely, if the troubles can be repaired very quickly, then they must be exceedingly frequent.

A Hypothetical Case

Assume a hypothetical calculator equipped with 1,000 tubes having 10,000 hours of life, and 10,000 diodes having 100,000 hours of life. Further, assume that there is no failure of soldered joints, wires, or anything else except tubes and diodes. Then, if the machine has been operating for some time, an average of 33 troubles per week is to be expected. According to Table 1 this machine will operate at 75 percent efficiency if each faulty component is located in 1-1/4 hours. Efficiency can be raised to 95 percent only if the troubles can be cured five times as quickly.

It is interesting to note that the 33 failures may be unevenly distributed throughout the work week, and that several troubles may occur in such rapid sequence that before one is located another may arise.

Probabilities of Troubles

The probabilities, P(m), of m breakdowns during an 8-hour shift can be found by using Bernoulli's Theorem. The data shown in Table 2* are derived from initial calculations that were based on the hypothetical machine operating 1,095 shifts per year and having 33 troubles per week.

*see page 10

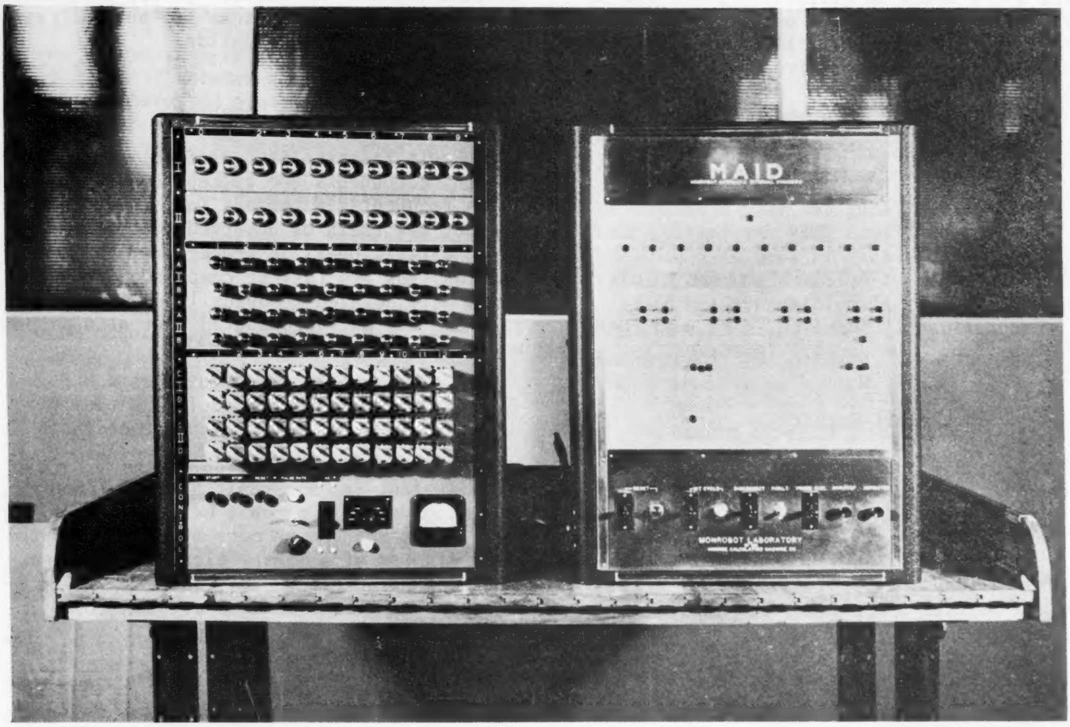


Figure 1. An electronic counter, and its associated MAID, Monrobot Automatic Diagnosis unit. The unit was constructed to verify the operation of the counter, and confirm the principles of automatic internal diagnosis. It worked.

Table 1

TROUBLE FREQUENCY, TROUBLE DURATION, AND COMPUTER EFFICIENCY

Frequency: Number Of Troubles Per Week	Average Trouble Duration: 75% Efficiency Hrs.	75% Efficiency Min.	85% Efficiency Hrs.	85% Efficiency Min.	95% Efficiency Hrs.	95% Efficiency Min.
1	42		25		8	
2	21		12		4	
4	10		6		2	
8	5		3		1	
12	3	30	2			40
25	1	40	1			20
33	1	15		45		15
50		50		30		10
100		25		15		5

Thus if you have 50 troubles a week, 15 minutes' average duration will allow you 95% efficiency but 45 minutes' average duration will reduce the efficiency to 85%.

At 75 percent efficiency each fault requires 1-1/4 hours to correct. Then one to four faults may be expected on 77 percent of the shifts, and these faults will require 1-1/4 to 5 hours of maintenance. Five or more troubles requiring over six hours of maintenance must be anticipated 29 times a year. Yet twenty percent of the shifts may be expected to be trouble-free.

It is evident that computer breakdowns are a serious problem. They are costly, and will on occasion result in long periods of idieness. Component failures are of course inevitable; hence, if maintenance technique can be significantly improved, then machine efficiency should be greatly increased.

Self-Repair

Automatic computing machines have been designed to perform operations otherwise handled by clerks. Why then do we not design automatic maintenance machines to perform operations otherwise handled by servicemen? Can't automation be extended to include not only arithmetic and logical operations, but repair operations as well?

The following steps are required where electronic calculating or switching circuits are to be maintained:

(1) Error detection
(2) Fault location
(3) Component replacement
(4) Error clearing (where necessary)
(5) Re-starting

Except for component replacement, each of these steps can be mechanized. Step (3), replacing components, is reasonably left to human beings. But the other tasks can be mechanized, by means of "automatic internal diagnosis", as will now be explained.

Error Detection

Numerous methods are available for error detection, but none offer certainty. The slow and more economical way is to perform each arithmetic operation twice and compare the results. The fast and more expensive way is to provide two or more complete machines and to compare their results continuously. Between these extremes are other means, such as error-detecting codes to represent decimal digits, and various types of parity checks that are applied to numbers and orders.

The most reliable method is comparison by the use of two or more machines. Alternative methods are susceptible to a special type of failure because the control gates, arithmetic unit, and selection systems are not fully verifiable except by duplication.

Fault Location

Fault location is a difficult task since so many components are susceptible to failure. It is frequently a tedious task to determine whether the train of observed pulses at any given circuit point is proper or improper. Difficulties are further compounded when circuits have delayed feedback loops so that errors are not only propagated, but also perpetuated in the apparatus.

Linear Networks

The first consideration is the linear circuit, that is, a circuit having no feedback. Each stage of this circuit will have one or more inputs and one or more outputs. On the block diagram of a linear circuit, it is possible to assign all inputs, outputs, and interconnecting leads between stages, unique integers, P_i, such that the inputs to each stage, P_j, and the outputs of each stage, P_k, satisfy the relation $P_j > P_k$ for all j and k associated with the stage.

To locate a fault in a network so labeled, it is possible to begin by examining the signal at the lowest valued point (an output), and progressively examine all points in ascending order. An error may be observed at one or many points, P_e. These points form a dendritic pattern, starting with a highest numbered point and branching to output extremities having lower numbered points. The highest numbered point lies nearest a circuit fault, while all other points lie along the signal propagation paths which stem from the fault.

Feedback Networks

Feedback circuits, which are basic to electronic calculators, consist of linear networks interconnected by delay elements. These elements may be flip-flops, integrating networks, delay lines, or other storage devices. For example, a serial adder is a linear network with a carry delay circuit acting as a feedback loop between carry output and carry input.

The location of a fault in a net with delayed feedback requires rigid discrimination between original errors and errors propagated via feedback. Due to a time delay that exists in each feedback loop, propagated errors may best be distinguished by their tardiness with

respect to original errors.

Diagnosis can be a simple matter where all points in a feedback system have been assigned unique numbers, and where the points in each linear network are assigned numbers as described above. A probe is sequentially applied to all points in the system. The time of error at each is recorded. When the probing is completed, only those points showing earliest time of error are considered. This set of points is part of a linear network, and that point of the set which has the maximum P_i is nearest the fault.

A determination of the time of error can be made absolutely or relatively.

The most straight-forward means for measuring absolute time in a calculator cycle is an electronic counter which counts pulses from the beginning of each cycle and is automatically shut off, or sensed, at the instant of error.

Relative time measurement can be performed as a sorting process. Assume a device capable of indicating which of two events occurred earlier in time. When presented with any two error points, the device will indicate which point showed an earlier error. It is this earlier error that may be compared with all other points until a point of even earlier error is detected. The process can be continued until all points have been examined and one set of points is known to show error earlier than all other points. To recapitulate, if these linear network points are numbered, then that point which has the greatest index number is nearest the fault.

Automatic Internal Diagnosis Equipment (AID)

By using the above techniques, trouble shooting of internal faults can be reduced to a routine that requires no special skill from the maintenance man. The logical rules which define the routine are so simple that the entire process can be mechanized with about a dozen relays and as many tubes.

When dual electronic units are provided, instantaneous error detection is available to the AID circuitry. The same error signals are used to stop calculation and thereby prevent the propagation of errors through subsequent steps in the program.

When an error is detected, AID makes an attempt to locate the fault, then automatically halts the calculator, and finally restarts it on the same program step. This process is repeated as long as the fault persists. If the fault is intermittent and the error disappears, calculation is allowed to proceed without interruption until the next occurrence of error. If the fault persists, thirty seconds are required for AID to narrow the trouble location to one point in the system and stop the calculator. The operator reads the final result from indicators mounted on the machine. A trouble shooting chart or schematic diagram then tells the operator which components or tubes may be responsible.

An average of two tubes and three component plug-in packages are covered by one AID point. Hence, removal of at most five units in each of the dual systems should suffice to correct any fault. After the operator has replaced the components suspected of fault, AID is reset manually and calculation resumed.

A number of simultaneous faults in different circuits are located by AID without difficulty. As each fault is corrected, AID goes to work to find another. Intermittent troubles are also located automatically even though the calculator resumes work for long periods of time after each error. AID points to the source of trouble and stops the machine after repeated occurrences of the error.

A valid question is: what happens when AID fails? It seems impractical to provide auxiliary AID units to diagnose the primary AID units. Instead, means are provided for automatically checking the circuits for the AID system as it is used. AID equipment is small enough so that its two chassis may be unplugged and replaced with new chassis in a few minutes.

Real-Time Operation

When real-time operation at extremely high efficiency is vital, the AID system can be extended to include three machines with automatic error detection and correction. In this manner work may continue uninterrupted and error free while automatic diagnosis is in progress. Under these conditions, parts can be replaced in one unit while the others continue operation.

(Table 2 on next page)

Table 2

BREAKDOWNS DURING AN 8-HOUR SHIFT FOR THE HYPOTHETICAL COMPUTER

Number of Breakdowns Per Shift, m	Probability of m Breakdowns, P(m)	Frequency of Occurrence (Shifts Per Year)
1	.322	320
2	.258	280
3	.137	150
4	.055	60
5	.018	19
6	.005	5
7	.001	1
0	.201	220
1 to 4	.772	845
5 or more	.027	29

* ——— * ——— *

MANUSCRIPTS

We are interested in articles and papers. To be considered for any particular issue, the manuscript should be in our hands by the 5th of the preceding month.

Articles. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $50 on publication. A suggestion for an article should be submitted to us before too much work is done.

Technical Papers. Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable. No payment will be made for papers. If a manuscript is borderline, it may be returned to the author to be modified to become definitely either an article or a paper.

Roster of Organizations in the Field of Computers and Automation

(Supplement, information as of August 3, 1954)

The purpose of this Roster is to report organizations (all that are known to us) making or developing computing machinery, or systems, or data-handling equipment, or equipment for automatic control and materials handling. In addition, some organizations making components may be included in some issues of the Roster. Each Roster entry when it becomes complete contains: name of the organization, its address and telephone number, nature of its interest in the field, kinds of activity it engages in, main products in the field, approximate number of employees, year established, and a few comments and current news items. When we do not have complete information, we put down what we have.

We seek to make this Roster as useful and informative as possible, and plan to keep it up to date in each issue. We shall be grateful for any more information, or additions or corrections that any reader is able to send us. (It has not been possible to include in this supplement all the additions and corrections which we have on hand; we hope to include many more in the next issue.)

Although we have tried to make the Roster complete and accurate, we assume no liability for any statements expressed or implied.

This listing is a supplement to the cumulative listing in the April issue of "Computers and Automation", vol. 3, no. 4, and the supplements in the May issue, vol. 3, no. 5, and the July issue, vol. 3, no. 6, and contains additions or corrections as compared with previous listings.

Abbreviations

The key to the abbreviations follows:

Size
- Ls Large size, over 500 employees
- Ms Medium size, 50 to 500 employees
- Ss Small size, under 50 employees (no. in parentheses is approx. no. of employees)

When Established
- Le Long established organization (1922 or earlier)
- Me Organization established a "medium" time ago (1923 to 1941)
- Se Organization established a short time ago (1942 or later) (no. in parentheses is year of establishment)

Interest in Computers and Automation
- Dc Digital computing machinery
- Ac Analog computing machinery
- Ic Incidental interests in computing machinery
- Sc Servomechanisms
- Cc Automatic control machinery
- Mc Automatic materials handling machinery

Activities
- Ma Manufacturing activity
- Sa Selling activity
- Ra Research and development
- Ca Consulting
- Ga Government activity
- Pa Problem-solving
- Ba Buying activity

(Used also in combinations, as in RMSa "research, manufacturing and selling Activity")

*C This organization has kindly furnished us with information expressly for the purposes of the Roster and therefore our report is likely to be more complete and accurate than otherwise might be the case. (C for Checking)

ROSTER

ANelex Corp., Concord, N. H., and 150 Causeway St., Boston 14, Mass. / Richmond 2-3400 / *C
High-speed printer (1800 characters per second), numerical and alpha-numeric up to 64 characters and line-lengths up to 120 characters. Ms Se(1952) DIc RMSa

Atomic Instrument Co., 84 Mass. Ave., Cambridge 39, Mass. / Eliot 4-4321 / *C
Analog-to-digital converters, printers, counter components and controls; shell velocity computation and recording; etc. Ms (100) Se(1947) DACc RMSCa

Automacité Appliqué, 10 rue Saulnier, Paris 9e, France
Automatic control apparatus. Cc RMSa

Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill. / Haymarket 1-4300 / *C
Automatic electrical systems, telephone equipment, relays, stepping switches, etc., for computing machinery and communications companies. Automatic control components. Ls(5700) Le(1892) ICc RMSa

Automation Consultants, Inc., 1450 Broadway, New York 18, N. Y. / Chickering 4-7800 / *C
Consultants in electronic systems and devices, including automatic information-handling. Ss Se(1953) Dc Ca

Automation Engineers Co., Division of Associated Industrial Consultants, 246 West State St., Trenton, N. J. / Trenton 3-2603 / *C
Consultants in automatic control machinery and automatic materials handling equipment. Ss(20) Me(1942) DACMc Ca

Beckman Division, Beckman Instruments, Inc., Fullerton, Calif. / Lambert 5-8241 / *C
Multi-channel digital data-handling systems; 200 channel strain gage recorder. Automatic process control, digital data handling and recording. Ls(1800) Me(1934) DAIc RMSa
Also see Berkeley Division, Beckman Instruments.

Bull, S. A. Compagnie des Machines, 94 Avenue

Gambetta, Paris 20e, France / MEN 8158 / *C
Punch card machines. Commercial electronic computers and card-programmed scientific computers. Producing about 10 electronic computers a month; 100 currently in operation. Ls(2500) Me(1931) Dc RMSa

Burlingame Associates, 103 Lafayette St., New York 13, N. Y. / Digby 9-1240 / *C
Analog computers, servo analyzers, servo-control devices, digital voltmeters, etc. Ss (35) Me(1928) AIc Ca

Coleman Engineering Co., 6040 West Jefferson Blvd., Los Angeles 16, Calif. / Vermont 9-7549 / *C
Digital data-handling systems and components; "Digitizer", device for converting rotational shaft positions into electrical contact settings; etc. Ms(100) Se(1951) DIc RMSa

Computation Centre, Univ. of Toronto, Toronto, Canada / Walnut 3-1327 / *C
Digital, electronic computers. Now operating: a Ferranti electric automatic computer; punch card machines. Ss(15) Se(1947) RPCa Dc

Computer Company of America, Division of Bruno-New York Industries Corp., 149 Church St., New York 7, N. Y. / Cortlandt 7-1450 / (formerly Computer Corp. of America) / *C
Analog computers, differential analysers, specialized computers and accessories. Ms(125) Se(1942) DAc RMSPa

Computer Control Co., 92 Broad St., Babson Park 57, Mass. / Wellesley 5-6220 / and 1429 Promenade Highway, Santa Monica, Calif. / *C
Computers and computer components, digital data-handling systems, solid delay-line acoustic memory, computer test equipment, dual beam conversion kits, specialized systems and instrumentation. Operating and servicing Raydac at Pt. Mugu. Ss(35) Se(1952) Dc RMSCa

Computer Research Corporation, Hawthorne, Calif.: Has become "The National Cash Register Co., Electronics Division", which see.

Computing Devices of Canada, Lim., P. O. Box 508, Ottawa, Ont., Canada / Parkway 2-6541 / *C
Custom-built digital and analog computers, automatic navigation systems, electronic laboratory test equipment, simulators, servomechanisms. Research and development in instrumentation, automatic control, business and scientific sorting, systems analysis. Ms(200) Se(1948) DASCc RCPMSa

Davies Laboratories, Inc., 4705 Queensbury Road, Riverdale, Md. / Appleton 7-1133 / *C
Automatic data-reduction equipment. Magnetic tape data recorders. Ms(85) Se(1946) Ac RMSCa

Eckert-Mauchly Division, Remington Rand, Inc., 3747 Ridge Ave., Philadelphia, Pa. / Baldwin 3-7300/ and elsewhere / *C
All purpose electronic digital computers. Univac Factronic System. Ls(600) Se(1946) Dc RCMa Also see Remington Rand, Inc.

Electronic Computer Div. of Underwood Corp., 35-10 36th Ave., Long Island City 6, N. Y. / Exeter 2-3400 / *C
Constructing five types of electronic digital computers (ELECOM-100, -120A, -125, -200, and a data-handling computer). Delay lines, decade delay lines, pulse transformers, magnetic recording heads, magnetic drums, D.C. plug-in amplifiers. Ms(200) Se(1949) Dc RMSa

L'Electronique Industrielle, 55 blvd de la République, Livry-Gargan, Seine-et-Oise, France
Automatic electronic measurement, counters, controls. Cc RMSa

Farrand Optical Co., Bronx Blvd and 238 St., New York 70, N. Y. / Fairbanks 4-2200 / *C
Gunfire control apparatus, rangefinders, optical and electronic sighting equipment, automatic trackers, infrared search and scanning systems, analog-digital converters, analog computers, etc. Ls(800) Le(1918) DASCa RMSCa

Ferroxcube Corporation of America, East Bridge St., Saugerties, N. Y. / Saugerties 1000 / *C
Ferrite core materials, including pot cores, cup cores, recording heads, and microminiature toroids with square hysteresis loop. Magnadur permanent magnet materials. Ms(150) Se(1950) Ic RMSa

General Cybernetics Associates, P.O.Box 987, Beverly Hills, Calif. / Vermont 9-0544 / *C
Industrial automation, computers, instrumentation, communication, industrial electronics; linear displacement transducers, digital converters, punch-card-to-tape devices, electronic gages for automation processes, medical electronics research and development; etc. Ss(18) Se(1953) RMSCa

G. M. Giannini & Co., Inc., Laboratory Apparatus Division, 918 Green St., Pasadena, Calif. / Ryan 1-7512 / *C
Digitizing analog devices, etc. Ms(100) Se (1952) DAc RMSa

Hammarlund Mfg. Co., Inc., 460 West 34 St., New York 1, N. Y / Longacre 5-1300 / *C
Remote supervisory control and industrial telemetering equipment. Ls(500) Le(1910) ICc RMSa

Imperial College, Mathematics Dept., Computer Section, Huxley Bldg., Exhibition Road, South Kensington, London, England
Automatic digital relay computer constructed and in operation. Constructing a second computer with neon tube storage. Ss Le (1922) Dc RMa

Institut Blaise Pascal, Laboratoire de Calcul Analogique, Paris, France: Combined with the Institut Blaise Pascal, Laboratoire de Calcul Mécanique, which see.

Intelligent Machines Research Corp., 1101 Lee Highway, Arlington, Va. / Jackson 5-6400 / *C
Devices for reading characters on paper, &c. Pattern interpretation equipment. Sensing mechanisms. Digital computer elements. Ss(17) Se(1951) Dc RCMSa

International Business Machines Corp., 590 Madison Ave., New York 22, N. Y. / Plaza 3-1900 / and elsewhere / *C
Punch card machines. Type 650, Magnetic Drum Calculator. IBM electronic Data Processing Machines, Type 701, Type 702 and Type 704 (magnetic tape, magnetic drum, electrostatic storage). Card Programmed Calculator. Electronic calculating punch Type 604 and Type 607. Data processing equipment. Automatic Source Recording Equipment. Ls(42,000) Le(1911) Dc RMSa

International Telemeter Corp., 2000 Stoner Ave., Los Angeles 25, Calif. / Arizona 8-7751 / *C
Systems and devices for clerical and control

applications. High-capacity rapid-access ferrite core memories. High-density photographic information storage. Community TV system equipment; pay-as-you-go TV. Ms(200) Se(1951) DCc RMSa

International Telephone and Telegraph Corp., 67 Broad St., New York 4, N. Y. / Bowling Green 9-3800 / *C
Equipment for automatic control of repetitive processes, clerical or industrial work, such as inventories. Fully automatic pneumatic tube system, by dialing. Ls(96,000) Le DASCMc RMSCPa

Kearfott Co., Inc., Clifton, N. J. / Gregory 2-1000 / *C
ADAC (Analog-digital-analog converter: servoed and direct drive): etc. Ls(3000) Le (1916) ISc RMSa

Ketay Manufacturing Co., 555 Broadway, New York 12, N. Y. / Digby 9-2717 / and elsewhere / *C
Automatic control systems; synchros, servomotors, resolvers; magnetic, electronic, and resolver amplifiers. Electronic equipment; servomechanisms; gears and components. Ls (2000) Se(1943) CISc RMSa

Librascope, Inc., 808 Western Ave., Glendale, Calif. / Ch. 5-2677 / *C
Mechanical and electrical computers. Computing and controlling equipment for military applications and for banking, department stores, inventory and production control, etc. Airborne digital computers. General purpose computer under construction. All phases of data handling. Ls(1200; approximately 350 on digital computers) Me(1937) DASc RMSa

Log-Abax Co., 146 Champs Elysees, Paris, France / LEC 9378 /
99-register automatic accounting machine. DIC RMSa

Marchant Research, Inc., 1475 Powell St., Oakland 8, Calif. / Piedmont 5-7435 / subsidiary of Marchant Calculators, Inc. *C
Electronic digital computers (including Miniac). Magnetic storage systems, magnetic heads, data processing equipment including analog-to-digital converter, computer components. Ss(55) Se(1950) Dc RMSa

Univ. of Michigan, Willow Run Research Center, Willow Run Airport, Ypsilanti, Mich. / Ypsilanti 5110 / *C
Digital computers, both special purpose and general purpose, including Midac and Midsac; electronic and electromechanical analog computers; simulators. Data-processing systems; analysis and computation using Midac and Midsac; instruction in programming and numerical methods; simulation; etc. Ls(500) Se(1946) DAc RCPa

The National Cash Register Co., Electronics Division, 3348 West El Segundo Blvd., Hawthorne, Calif. / Osborne 5-1171 / *C
Digital computers, data processing machines, decimal digital differential analyzers, computer components, input-output devices, computing systems. CRC 102-A and 102-D general purpose computers and other computers. Ms (350) Se(1950) Dc RCMSa

National Co., Inc., 61 Sherman St., Malden, Mass. / Malden 2-7954 /
Communications receivers; some computing equipment. Ls(700) Ic RMSa

Nuclear Development Associates, 80 Grand St., White Plains, N. Y. / White Plains 8-5800 / *C
Circle Computer design and sales; special purpose data-handling systems, and systems design. Associated with Hogan Laboratories. Ms(100) Se(1948) DIc RMSa

Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y. / Great Neck 2-0532 / *C
Electronic counters. Magnetic tape handler; digital printer. Shift registers. Magnetic core memory. Random access memory. High speed printer ("Flying Typewriter"). Analog-to-digital converter. Ms(100) Se(1942) Dc RMSa

The Rand Corporation, 1700 Main St., Santa Monica, Calif. / *C
Electronic digital computer (Johnniac) constructed and operating. Ls(600) Se(1946) DAIc RCPa

J. B. Rea Co., Inc., 1723 Cloverfield Blvd., Santa Monica, Calif. / Exbrook 3-7201 / *C
Magnetic drum computers; analog and digital computing service; high-speed analog-to-digital converter (Reacon). Ms Se(1951) DACc RMSCPa

Remington Rand, Inc., 315 4th Ave., New York 10, N. Y. / Spring 7-8000 / and elsewhere / *C
Digital computers (Univac System, ERA 1101 Electronic Computer System, ERA 1103 Electronic Computer System); analog computers; special purpose computers. Card-to-tape and tape-to-card converters. Servomechanisms, magnetic drum storage systems, input and output devices. Adding and calculating machines. Punched-card accounting machines and other accounting machines, etc. SEE also Eckert-Mauchly Division and Engineering Research Associates Division. Ls(over 30,000; 1800 on computers) Le DASc RCMSa

Shepard Laboratories, Summit, N. J.
High-speed typer (up to 1800 characters per second). Ss Se(1950) DIc RMSa

Societe des Servomechanismes Electroniques, 1 rue Chanez, Paris 16e, France
Sc RMSa

Sprague Electric Co., 377 Marshall Street, North Adams, Mass. / *C
Capacitors: miniature, and low dielectric hysteresis loss, for computer applications. Standard capacitors; precision and power type resistors; pulse transformers; radio interference filters; printed circuits. Ls (5,000) Le(1926) Ic RMSa

Telecomputing Corp., 133 E. Santa Anita Avenue, Burbank, Calif. / Charleston 0-8161 / *C
Automatic data reading, recording, and plotting equipment. Automatic business data accumulation and analysis equipment; multiple access storage systems. Ms(250) Se(1947) DCMc RMSPa

Telequipment Corporation, Sea Cliff, N. Y.
Simple equipment for attaching to an electric typewriter so that it may be operated by five-hole punched paper tape. Ss Se Ic RMSa

Teletypesetter Corporation, 2752 Clybourn Avenue, Chicago 14, Ill. / Graceland 7-5250 / and elsewhere / *C
Tape perforators and operating units for local or distant automatic control of Linotypes and Intertypes. Ms(57) Me(1929) Ic RMSa

(continued on page 28)

THE COST OF PROGRAMMING AND CODING

C.C. Gotlieb
Computation Centre, University of Toronto, Toronto, Canada

Much has been said at recent computer conferences about the high cost of writing programs for electronic digital computers, but it has been surprisingly hard to get details of the actual cost for such programs. The problem of assembling such information runs into a usual difficulty in cost accounting, namely the impossibility of finding general principles which cover the wide variety of cases in practice. Nevertheless, estimating the cost of calculation is so difficult that any guide would be useful. In what follows, attention will be limited to programming and coding costs only. These costs consist of the cost of expressing the mathematical representation of a problem in a form suitable for an electronic computer, and of preparing a workable set of instructions to carry through the program on a particular machine. When doing a problem there are additional costs for translating the problem from physical into mathematical terms, for the preparation and handling of data, and for the running of production cases.

Our interest in programming costs arose when we came to examine the records of time spent and results achieved in writing a program library for FERUT, the Ferranti computer at the University of Toronto. We expressed the cost as the price per (single address) order. The result that appeared seemed so high that we had to find confirmation from other sources before accepting it as reasonable.

First Estimate: Cost Per Single Address Order

Between October 1, 1952 and September 30, 1953, twenty new library routines were written for FERUT. In addition, the equivalent of ten routines was written in adapting sixty programs from the Manchester computer to the Toronto input scheme. These routines varied considerably in size and scope, the largest being a system of matrix operations requiring about 2500 orders. By counting the number of orders in the total library (13,500) it was determined that about 4500 orders were written at Toronto during this time for library purposes. Altogether a total of 131 man-weeks and 143 machine-hours were required for this work. These programs were written by people with varying degrees of experience, including several juniors in training. The total salary for the work was $9000 and the machine was valued at $60 per hour at that time, so that the machine cost was approximately $8500. Thus the cost might be given as $17500 for 4500 orders, or approximately $4 per order.

There are so many qualifying features about this estimate, and so many factors which must be considered before applying the result elsewhere, that it is best to summarize these before proceeding further.

Factors Which Make the Estimate Too Low

1. No allowance has been made for overhead on the salaries of the programmers. Overhead would include payments for: space; office, purchasing and accounting department facilities; contributions towards pension schemes; etc. This varies greatly in different organizations but allowance for overhead could easily double the salaries concerned.

2. The machine rate of $60 per hour is low. It was set to meet current operating costs only, and did not cover depreciation, library costs, or profit.

3. These are Canadian costs which are somewhat lower than U.S. costs, as far as salaries are concerned.

Factors Which Make the Estimate Too High

1. The $4 cost per order is the cost for writing library routines. Coding for these routines is generally more expensive than for ordinary problems, because it is much more important to use tricks for saving space and time.

2. Few special aids for writing and verifying programs were used. These were not available then, and in fact an appreciable part of the library work was concerned with developing them.

3. Salaries constitute the larger part of the cost here; in other work they might be relatively less important. For problem formulation and programming highly skilled people are indispensable. For coding, junior people and trainees can be used, but the result is more expensive than it would be with skilled coders. Of course if the routines are written free of charge by people who are learning about computers, as might be the case in a university, the resulting costs would be altogether different.

Other Factors

1. Library routines are often short computations with a clear mathematical formulation readily available. For the work on which this estimate was based, several comprehensive programs for input organization, matrix operation, code checking and floating point operation were written. The programming was quite elaborate and considerable effort was spent before the actual coding was even started.

2. The order code for FERUT is rather difficult. This makes the cost per order higher but the increased flexibility makes fewer orders necessary, so that the overall price for a routine is probably not affected too seriously.

With all these complications, it is hazardous to venture an estimate of cost that would cover all programs. Nevertheless, I believe that where an electronic computer program is not written by some automatic method, the cost will be between \$2 and \$10 per (single address) order. This range may seem to be so large that it may not be very informative; but even the lower limit is probably greater than most programmers would be willing to concede on an off-hand guess. Fortunately, there is corroborative evidence from several sources.

Other Evidence

Macon of International Business Machine Corporation has done a cost analysis of the programming for a fairly large problem (about 4000 orders), written for the IBM 701 Electronic Data Processing Machine. Also, it turned out that, on the average, 40 orders were written and verified per man-day; this is another way of seeing why programming costs are so high. The investment in programming for each IBM 701 has been estimated as \$100,000 to \$500,000. Note that on the basis used for estimating above, the total FERUT library of 80 routines is valued at \$70,000 and in view of the lack of overhead on salaries for the FERUT figure, these library costs for FERUT and the IBM 701 are not incompatible.

Clippinger, Dimsdale and Levin of Raytheon Manufacturing Co. discuss the whole cost problem for an electronic computer installation in a series of articles appearing in the first issues of the "Journal of the Society for Industrial and Applied Mathematics". They point out that programming and coding time may vary from a few man-days to several man-years, but that most problems take several man-months. They analyze costs for carrying out an optical ray tracing problem on three different machines with operation rates varying from 60 to 6000 operations per second. (In comparing machines with different numbers of addresses per operation, they take a four-address operation as being equivalent to 1 three-address operation, 1.5 two-address operations or 2 single address operations.) It is interesting to note that the estimate of programming and coding costs all lie between \$25,000 and \$30,000, which indicates that these costs do not vary greatly from machine to machine.

Reduction of Programming Costs

Although only a preliminary basis for assessing programming and coding costs has come out of the above discussion, these costs are clearly high, and the obvious question is: What can we do to reduce them? A great part of the activity of programmers, when not engaged in producing the solution for an individual problem, has been directed towards answering this question. In order of their degree of newness, three main ideas have come out.

1. Have the machines themselves do all the coding and if possible the programming too -- automatic programming.

2. Develop special routines for efficient production and checking of codes.

3. Accumulate a library of sub-routines which can be embodied into a problem with little or no effort.

Automatic Programming

The current emphasis on automatic programming offers considerable hope of relief. It has been stated that the overall time between the start and finish of a problem can be reduced by a factor as much as 100 with an automatic program, but it is not likely that such a large factor will usually apply. Work on automatic coding has just begun, and much remains to be done, but even when it has progressed further there will be important areas where it will not be used. Thus for frequently used library routines, and for problems which run on a regularly scheduled basis, it is important to have high efficiency, and a program written by a human being will usually be preferable. It is true that a machine can do optimum programming, i.e. produce codes where the waiting period for instructions is designed to be a minimum, but for important cases, hand tailoring would seem to be necessary. It is hard to believe that we can program into a machine all the human ingenuity which has already been shown in writing programs.

(continued on page 25)

RECIPROCALS – A NOTE ON A COMPUTER METHOD FOR FINDING THEM

Andrew D. Booth
Birkbeck College Research Laboratory, London, England

At the present time many automatic digital computers do not have special instruction for performing the operation of division. This means that some sub-routine has to be used, and the particular process which is usually quoted is based upon the well-known iteration:

$$x_{n+1} = x_n(2 - ax_n) \quad \ldots (1)$$

which, when it converges, gives:

$$\lim_{n \to \infty} x_n = 1/a$$

Thus, to divide b by a, the reciprocal 1/a is formed by means of (1) and this is then multiplied by b to give the required result.

Now the actual use of (1) on a computer brings to light an immediate difficulty, since most machines operate with a fixed decimal or binary point which is often so placed that only numbers in the range $(-1 \leq x < +1)$ can be handled. In forming 1/a the difficulty is that, if a is in the required range, then 1/a is not and vice versa. To overcome this trouble it has been a common practice to arrange, by suitable shifts, that the number a is brought into the range $2 > a \geq 1$ and to proceed from there. To make this clear, assume that b/a is to be formed, where b and a are numerically less than unity, and b is numerically less than a. Under these circumstances b/a is less than one and is, in consequence, understandable by the machine, on the other hand 1/a is greater than unity and so cannot directly be handled. The difficulty is overcome, in a binary machine, by multiplying a by some power of two, 2^p, so as to bring it into the range $2 > 2^p a \geq 1$. The reciprocal is then found from (1) and b is multiplied by this number. Finally, the result is multiplied by 2^p to give the desired quotient b/a.

The only point which remains to be discussed is the choice of an appropriate starting value for use in the iteration (1). Various methods have been suggested; for example, an abbreviated table of reciprocals may be held in the computer store and used to find a reasonable first approximation to 1/a. Alternatively the value 1/2 may always be taken as the first approximation. It will now be shown how the actual optimum starting value can be found.

First assume that the first approximation, x_0, differs by a quantity $\pm e$ from the true reciprocal. Equation (1) then gives:

$$x_1 = x_0(2 - ax_0) = (1/a \pm e)\ (1 \mp ae)$$
$$= a(1/a^2 - e^2) = 1/a - ae^2$$

and a repetition of the process shows that:

$$x_n = 1/a - a^{(2^n - 1)}\ e^{2^n} \quad \ldots (2)$$

so that, if the sequence is to converge,

$$\lim_{n \to \infty} a^{(2^n - 1)}\ e^{2^n} = 0$$

which leads to $ae < 1$. Whence, since a lies in $(2 > a \geq 1)$, for convergence the initial error must lie in the range $(0 \leq e \leq \frac{1}{2})$. This, in turn, implies that the initial value, x_0, can be chosen so as to lie anywhere in the range $(\frac{1}{2} \leq x_0 \leq 1)$, and the problem is to find which single value within this range will give the most rapid convergence in all possible cases.

The question is easily answered by reference to (2), for consider the two extreme cases, $a = 1$ and $a = 2 - d$ where d tends to zero. It is required that in the limit, as n tends to infinity, the given initial value gives the same accuracy at both extremes and for the same number of iterations. Thus:

$$(2 - d)^{(2^n - 1)} \cdot \left(x_0 - \frac{1}{2 - d}\right)^{2^n}$$

$$\rightarrow 1^{(2^n - 1)}\left(1 - x_0\right)^{2^n}$$

or: $$x_0 = 2/3 + g$$

where g tends to zero as the number of steps in the iteration is increased.

To show the working of the iteration process with $x_0 = 2/3$ as the initial value, the H.E.C.1. computer has been used to produce the sequences shown in Chart 1. These show the actual accumulator contents, in binary scale, at the end of each stage in the iteration; and confirm that the initial approximation 2/3 (equal to .101010 ....) results in a process

(continued on page 25)

Roster of Magazines Related to Computers and Automation

(Cumulative, information as of August 3, 1954)

The purpose of this Roster is to report magazines having some relation to the field of computers and automation: computing machinery, computing systems, data-handling equipment, automatic control, automatic materials handling, etc.

Each Roster entry when it becomes complete contains: name of the magazine / frequency /publisher and address / emphasis / audience and availability / circulation / advertising / some notes and comments. We shall be grateful for any additions or corrections that any reader is able to send us. Although we have tried to make this Roster complete and accurate, we assume no liability for any statements expressed or implied.

For more information about any of these magazines, inquiry should be addressed to the publisher of the magazine.

Automatic Control / monthly / Reinhold Publishing Co., 430 Park Ave., New York 22, N.Y. / emphasis: aid management in making more and better use of automatic control in every possible way / free to management men in the control field; $10.00 annual subscription to others /30,000 / contains advertising.

Vol. 1, no. 1, July, 1954, has been issued. Contained one article on computers.

Automation / monthly / Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio / emphasis: management, supervision, and engineering phases of automation in their broadest sense / free to selected prospective buyers or specifiers of components, machines, or equipment involved in automatic operations; $10.00 annual subscription to others / 20 to 30 thousand? / contains advertising.

Vol. 1, no. 1, August 1954, has appeared. Contained one article on computers.

Computers and Automation / monthly / Edmund C. Berkeley and Associates, 36 West 11 St., New York 11, N.Y. / emphasis: articles, papers,and reference information on computers and automation / directed to persons interested in automatic computers and their implications and applications, including automation; paid-for; annual subscription rate $4.50 / 1200 /contains advertising.

Control Engineering / monthly / McGraw Hill Publishing Co., 330 West 42 St., New York 36,N.Y. / emphasis: use of a small amount of power to control a large amount / directed to design and process engineers and technically trained management men; paid-for, annual subscription rate? / projected 15,000; 10,000 on August 1 / contains advertising.

Vol. 1, no. 1 is to be Sept., 1954.

Digital Computer Newsletter / quarterly / Office of Naval Research, U.S. Navy Dept., Washington 25, D.C. / emphasis: news of digital computers and data-processing / available free to government agencies and government contractors only; reprinted in the "Journal of the Association for Computing Machinery", which see / est.1000 / no advertising.

Electronic Design / monthly / Hayden Publishing Co., 127 East 55 St., New York 22, N.Y. / emphasis: electronic design / circulation only to electronic design engineers / 23,000 /contains advertising.

Relation to computers and automation is the design of electronic gear that may be used in equipment for such purpose.

Instruments and Automation / monthly / Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 1, Pa. / emphasis: instruments, instrumentation, and automatic control / directed to management and engineers primarily responsible for the specification, purchase,and installation of instruments and automatic controls; paid-for; annual subscription rate $4/ 18,000 / contains advertising.

Changed name from "Instruments" to"Instruments and Automation", effective January, 1954.

ISA Journal / monthly / Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Pa. / emphasis: instruments and instrumentation, and news and information for members / directed to members of the society; paid-for; annual subscription rate $5 / about 8200 / contains advertising.

Vol. 1, no. 1, was January 1954.

Journal of the Association for Computing Machinery, 2 East 63 St., New York 21, N.Y. / emphasis: technical papers on automatic computing machinery submitted by members / directed to members of the association; annual subscription rate $6 (includes dues) / est. 1500 / no advertising.

Vol. 1, no. 1, was January 1954.

Mathematical Tables and Other Aids to Computation / quarterly / National Research Council, Washington, D.C. / emphasis: mathematical tables, numerical analysis, some developments in computing machinery / directed to mathematicians, computer men, etc.; paid-for; annual subscription rate $5 / est. 1500 / no advertising.

Proceedings of the IRE / monthly / Institute of Radio Engineers, 1 East 79 St., New York 21, N.Y. / emphasis: technical developments in radio, electronics, television, communication, etc. / directed to members of the IRE, radio engineers, etc.; paid-for; annual subscription rate about $13 (includes dues) / about 38,000 / contains advertising.

Occasional technical papers on electronic aspects of computers, submitted by members. The October 1953 issue was devoted to computers.

Proceedings of the IRE Professional Group on Electronic Computers / quarterly / IRE PGEC, Institute of Radio Engineers, 1 East 79 St., New York 21, N.Y. / emphasis: technical papers on electronic computer developments / directed to members of the group; paid-for;

(continued on page 25)

THE DEVELOPMENT AND USE OF AUTOMATION BY FORD MOTOR COMPANY

News Department, Ford Motor Company
Dearborn, Mich.

The development known as "automation" has started what some observers call the second industrial revolution. As an industrial innovation, it has been ranked second in importance only to the moving assembly line, first conceived and put into operation by Henry Ford at his Highland Park, Mich., plant in 1913. The following report covers the development and use of "automation" by Ford Motor Company.

The Word "Automation"

The word "automation", we believe, was originated by D. S. Harder, a vice president of Ford Motor Company, in order to describe rather a restricted concept: a system for the automatic handling of parts between progressive production processes. As the word became more generally accepted outside of Ford, it gathered additional meanings; it is now sometimes used to denote an entirely automatic factory.

Although automation at Ford conserves manpower, it does not eliminate men from the industrial scene, producing an "entirely automatic factory." Instead it saves men from many burdens and hazards of industry and gives them jobs which utilize their brainpower more effectively. "What we have is a rather tremendous improvement over past methods," according to Vice President R. H. Sullivan.

Automation, though a new word, is not a new idea. It refers to a recent technological development in the automobile industry. Technological changes have been historically characteristic of all American industries, and account for the past rise in the American standard of living. For example, the petroleum and chemical industries, food and beverage processing industries and such non-manufacturing organizations as the telephone services have mechanized their operations to an extremely high degree without particular notice being taken by the public of the advancing technology. And a processing operation which approached complete automaticity has been reported dating from 1784-1785. In a flour mill operated by Oliver Evans on the edge of Red Clay Creek near Philadelphia, grain was fed into the mill by bucket conveyor, with water power moving it over a series of endless belt and screw conveyors through coarse and fine grinding operations until flour emerged from the other end.

Exactly when we first visualized the concept of "automatic handling of parts between progressive production processes" has not been established. Certainly the idea was developed before the word "automation" was coined.

The word, however, made its formal debut when a section of Ford production engineers whose job was designing work-handling devices was renamed the Automation Department. This dèpartment began operation in April, 1947.

Development of Automation

Automation grew up in Ford in small stages. The first application was on a valve guide bushing -- a small cylindrical cast iron part, larger in diameter on one end than on the other. The automatic handling came into play by a method of turning these parts so that the large end always first entered a conveyor which took them through the machining operations.

These parts were simply slid down a slotted trough. The slot was wide enough, but too short for the bushings, thus forcing the parts to tilt. Because the large end was heavier, the small end could pass over the slot without dropping; only when the large end passed the opening did the piece drop. Thus no matter which end passed first, each piece always fell with the large end down.

Imagination of this kind soon began to be applied at Ford to the handling of many other items. Automation's first really spectacular success occurred when it was applied as a means of loading and unloading stamping presses. First Ford use of "iron hand" and other mechanical lifting and turnover devices for steel sheets was in the Dearborn Stamping Plant. Another early use of automation was to transfer hot, heavy coil springs from a coiling machine to a quench tank, a job which before automation was called "mankilling," because the operator had to reach down, lift the hot part to chest height, turn around and put it in a compression fixture for quenching, all within seconds.

The early successes led Ford to design a complete plant around the automation concept. This was the Buffalo Stamping Plant which went into operation in September, 1950.

The second and third plant-wide applica-

tions of automation by Ford were made in 1951 when the company opened its Ford 6-cylinder and Mercury V-8 engine plant and foundry at Brookpark, Ohio, near Cleveland.

These three plants and especially the engine manufacturing operations have become symbols of automation to industry and to the public at large.

Present Extent

Now, every manufacturing plant which Ford operates makes use of automation to some extent. The latest facility to be extensively automated is the Dearborn Engine Plant where Ford and Lincoln V-8 engines are produced. The Dearborn Iron Foundry is undergoing the automation transformation. A second engine plant adjacent to the Brookpark facilities, and a stamping plant in Walton Hills, another Cleveland suburb, are under construction, both to be highly automated.

Automobile assembly plants, which are normally conveyorized to a high degree, are also sharing in the automation trend. The company is now building new assembly plants at Louisville, Ky., Mahwah, N. J., and San Jose, Calif.

Automation Engineers

Although started out as a centralized company function, with the Automation Department as the focal point, automation has since followed a decentralized pattern and now the company has automation engineers in the manufacturing engineering department of each plant. The over-all company operation which provides functional supervision is the Plant Layout and Industrial Process Equipment section of Manufacturing Engineering Staff.

Automation, despite its formal definition, now involves more than a system for handling parts. It is a means by which limitations in tools and other production processes can be overcome. Initially, Ford automation devices were designed which would position a part exactly as needed for a processing operation. The processing operation itself, and the part to be processed, were the same ones which were in existence without automation.

As the automation concept grows in our company, however, men of vision realize that the use of automatic handling devices opens up far greater vistas. Only the surface of automation's potential in improving processes and products has so far been scratched, in the opinion of Ford's manufacturing and product engineers.

Transfer Machines

Before automation reached its present development, another manufacturing innovation made its debut. For high-volume operations, such as the automotive industry has, some companies in the machine tool industry developed "transfer" machines. A typical transfer machine consists of a series of self-contained machining units linked together internally with a conveying device. A work-piece fed into one end of this machine is taken through all the machining operations of that machine before being discharged at the other end. A parallel development by stamping press manufacturers has been the design of progressive dies to perform several shaping operations successively on a piece of metal. The transfer machines may be thought of as employing automation internally.

The advent of the transfer machine brought about startling changes in manufacturing processes and facilities. As an example, automobile crankshafts require at one step of production the drilling of six oil holes, six metering holes, six holes for weight reduction, and inspection. Ten years ago at Ford, 29 separate machines were required for these operations. Today, the job is done with three transfer machines.

Automation has been applied by Ford to link separate transfer machines into what can fairly be called <u>one</u> transfer machine. As an example, at the Cleveland Engine Plant, a series of 42 transfer machines has been joined by automation devices which correctly and automatically position the work-piece (in this case an 180-pound cylinder block casting) for each successive machining operation. From the time the cylinder block is deposited at the entrance end until it emerges 530 cutting and drilling operations later, it has not been touched by a man. It has gone through more than an acre of machinery automatically; its quality has been thoroughly inspected — often by automatic gaging equipment, and it is ready for assembly.

Reflex Nervous System

The machines in this cylinder block "department" do not require operators. All the machines are controlled through an interlocking system of electrical switches and relays which function very much like a man's reflex nervous system. Just as a man's foot kicks when his knee is rapped by a physician's mallet, an automation device rotates or otherwise positions the engine block casting when an electrical switch is tripped by the part as it passes a certain point.

The complex electrical systems of these automated lines do not require men to push buttons to make them work. Instead, the electrical nerve center, which consists of commercially available switches and relays commonplace in industry, continually receives hundreds of bits of information from electrical switches acting as "look-outs" along the machining line. From this information, the nerve center can "decide" which block to move, which machine tool is ready for action, whether the machining operations are being performed accurately. There is no need in this type of operation for electronic computers -- for a master control panel from which one man directs all the machinery. This automation equipment tells itself how it's doing and which course of action is best.

The Use of Human Brains

Men, however, are vital to this operation. More vital, in fact, then the individual machine tool operators in a conventional factory.

Automation makes the smallest element in a production line as important as the largest. And the only way now known to keep machinery or equipment in operation is with skilled men who know how to spot trouble developing and to take steps to correct that trouble.

Statements of two Ford executives on manpower requirements of automated production facilities answer the worries in some quarters that man is being replaced by machines.

Mr. R. H. Sullivan, who as vice president and group executive directs the operations of the company's Engine and Foundry Division, Metal Stamping Division and Parts and Equipment Manufacturing Division, recently stated:

"While automation may reduce the direct labor factor in a given plant, it increases greatly the demand for skilled maintenance and repair technicians. We may need fewer sweepers (because metal chips and other manufacturing debris are disposed of automatically), fewer unskilled workers with monkey wrenches, but we need many more engineers, electricians, inspectors, mechanics, electronic experts, tool and die designers and makers, and the hundred and one other specially skilled workers required to keep the tremendously complex production lines in working order."

He further pointed out that "the growth of automation will create many new jobs in the electronic, machine tool and other industries engaged in building new automated factories. Those industries, in turn, will have to expand their own facilities in order to meet the growing demand, and that in turn will provide jobs ...."

D. S. Harder, vice president - manufacturing, says: "We can sum up the manpower situation in the factory of the future by saying that there will be much greater use of brain power throughout the entire plant to replace a large portion of the muscle power which we have been accustomed to in the past."

Productivity

An increase in man's productive capacity is regarded as the only means to achieve an ever-rising standard of living. One observer developed figures showing that to provide for the same standard of living increase which the United States experienced between 1940 and 1950, an increased output of approximately 43 per cent per worker will be required in the decade from 1950 to 1960.

Many authorities believe that by 1960 the United States' large population gain -- particularly in the very young and relatively old age groups -- will be relatively greater than the increase in the available work-force. To meet the demands of this larger and partially non-productive population, increased productivity per worker is essential.

Commenting on America's already superior productivity, John S. Bugas, Ford Motor Company vice president - industrial relations, said: "The fact that there is more output of goods and services and products of all kinds in the United States per man hour than in any other locality on the globe has really accounted for the difference in strength and influence between the United States and the rest of the nations of the world. In a very real sense the position of leadership in which our nation finds itself may be attributed very directly to the progress we have made in productivity."

Loading and Unloading

Automation is a means by which still higher productivity can be attained. The muscle power required to load and unload machine tools, to lift sheet steel into and out of stamping presses and to turn parts over to examine them for quality can be conserved. Machinery then works for the man, not the reverse.

Automation will change the composition of the factory work force. That is, there will be a greater percentage of skilled workers. This in turn will not only place a heavier demand on the labor market for more technicians, but will bring about new opportunities for the active work force.

Inherent in some machine tools and other manufacturing equipment is a productive capacity in excess of the physical ability of men

to load, unload and operate. Put automation into this system, and the equipment can be operated at a much higher rate. The mechanical loading system is as fresh at the end of the day as at the beginning.

However, some conventional manufacturing equipment has been designed with its operator's limitations in mind. Automation engineers have seen that these built-in limitations could be removed. Stamping presses at Ford, for example, which are engineered to take advantage of automation, operate much faster and more continuously than those in most other high-volume stamping plants.

Ford automation engineers try whenever possible to use equipment of an "in-line" nature, i.e., put the part into one end of the line and pass it out at the other end. Not all automated equipment used at Ford, however, meets this ideal situation. In the case of a commercially available crankshaft lathe, for example, the 70-pound work-piece must be inserted and removed at the same location. However, extremely satisfactory automation has been built into this machine in the form of a traversing fixture which picks up the work-piece at one side of the machine, takes it to the cutting tools, then travels to the other side of the machine and releases it to the next machine.

Specialized Automation and Generalized Components

A relatively little realized feature of Ford's automated operations is their high specialization. Such a thing as a "standard" automation machine simply does not exist. If a Ford plant is established to make stamped parts, or to perform forging operations, or to turn out automobile engines, it can do only those specific operations. The automation device that will satisfactorily feed stamped steel sheets one at a time into a welding press cannot be changed to handle a tubular rear axle housing. But many of the components of an automation device -- its air or hydraulic cylinder, or its electrical limit switch, for example -- can be common to many other automation devices which handle dissimilar parts. As the catalog of standard components grows through experience, the easier it becomes to design an automation fixture to do a particular job.

This is being demonstrated at the Dearborn Engine Plant, where the automation designers took advantage of their experience at the Cleveland Engine Plant. Fixtures which turn and position engine parts before feeding them into the transfer machinery are more simple in appearance and in maintenance requirements than earlier devices. At the same time, they have also become cheaper and more positive in operation.

At the Cleveland plant, "turnover" fixtures were put into the line only when necessary to revolve a work-piece for the next operation. In the Dearborn plant, they are incorporated for such seemingly unimportant functions as shaking out the metal chips after a drilling operation, or draining the cutting lubricant so it won't drip onto the floor as the work-piece moves from station to station.

Some observers, viewing the complexity of automated systems, wonder whether such operations have any application outside of the very largest plants. The same question used to be asked often about moving assembly lines; yet many relatively small companies now find it profitable to employ them.

Every spot where automation is used in Ford has been subjected to economic analysis. To be worthwhile at all, an installation must produce results in terms of increased production, lower costs, better working conditions, greater safety or other benefits. Maximum economies of automation can be realized, however, only when it is considered as a tool to do a given task, as compared with every other type of available tool.

Preventive Maintenance

Maintenance is a necessity in every industrial operation. But it is not enough to repair automation equipment after something interferes with its correct functioning. Preventive maintenance -- taking care of the equipment before trouble develops -- is vital. With each machine dependent upon every other one in an automated department, Ford has established a preventive maintenance program of major proportions. A standardization program applying to tools, methods and materials is fundamental.

Ford also has adopted a "tool control board" system as an important element of the ever-present necessity for changing tools before they begin to do an inferior job of machining.

These vari-colored, well-lighted boards stand out among their surroundings of machine tools in all Ford manufacturing operations having transfer machines. They contain a reserve supply of all the tools required for a given machine, a time-saver in tool changing. In this connection, the "satisfactory" life of each tool in a transfer machine has been carefully calculated and "pre-set" on the tool board's counting device. This tallies each part as it is processed in the machine, and when the life expectancy of the tool is used up, a light on the board signals the job-setter to replace the machine's tool with the tool which is in reserve. The replaced tool is then reground and put back in the board for future use.

When the machine tool is taken out of operation for replacement of that particular tool, the job-setter scans his tool control board for any other tools which are approaching the end of their life expectancy and these tools are simultaneously replaced. The result is that shutdown time of that machine tool is reduced to an absolute minimum, and the tools are changed before they can start to cause defective production.

Automatic Inspection

This is one instance of the improvement automation makes in the product's quality. Many others can be cited. Between many machining operations in Ford's Cleveland and Dearborn engine plants, there are automatic gaging devices. One of the most common types consists of steel "fingers" which reach into the part and "feel" that every hole has been drilled to the proper depth. If interference is noted -- caused either by an improperly functioning drill or by a piece of a broken drill, the gaging device automatically signals the previous machine tool to stop until the source of the trouble is located and repaired.

Because parts are transferred smoothly between manufacturing operations, there is no possibility of them being knocked against each other to cause damage, and they are treated more gently by massive steel transferring devices than might be the case if they were "manhandled."

To protect the machine tools against damage from an oversize part, automatic "qualifying" gages are set up at some sensitive locations. A part which is too large will be rejected automatically.

Finished and semi-finished parts are also subjected to thorough inspection, often by semi-automatic equipment using electronic or other newly developed methods of finding flaws which might escape human detecting. Piston pin inspection machines, for example, automatically check the parts for length, diameter, hardness and three other characteristics, rejecting all pieces which fail to come up to standard. Crankshafts are gaged for balance by electronically controlled devices which spot any imbalance as the part is rotated, and direct cutting tools to remove exactly the right amount of metal at the right place to bring the crankshaft into perfect balance.

Conveying

Contributing directly to the quality of engines produced are conveyor systems at the Dearborn and Cleveland engine plants which relieve the men and women on the assembly lines of most of the heavy work normally necessary in engine assembly. Thus, these employees can devote their entire attention to the precision assembly jobs without having to do tiresome engine lifting or moving.

Called "power-and-free" conveyors, these systems consist of overhead monorails on which hanging "arms" ride. Heavy engine blocks remain attached to these mechanical arms while complete engines are assembled, tested and placed in racks for shipment to automobile assembly plants.

The systems have several features which conserve manual effort. First, the arms can be turned in two planes -- vertical and horizontal -- so that the engine block can be rotated to the exact angle for easy placement of each component. Second, the monorails have "free" stations to which the arms can be sidetracked. At these points, as much time as necessary can be taken to perform any special operations on the engine. Third, the arms have electrical limit switch trippers which will automatically route the attached engines to any adjustment station if the engine test run shows the need.

There is no central control system for these power-and-free conveyors because, like the automated machining lines, the automatic controls are built-in throughout the system. Switching from one station to another is automatic, and if one station is not ready to receive the mechanical arm, the arm by-passes that station and comes back to it automatically when it is unoccupied.

Assembling

Parts assembly is not automatic in Ford's automated plants. However, the automation concept has done much to eliminate the drudgery from assembly operations. Cylinder head assembly, for example, is performed on a machine in which assemblers place the component parts in proper sequence and the machine itself then compresses the springs and slips retainers into place.

Assembly of parts at Ford's stamping plants also has most of the muscle-tiring elements removed. By use of conveyor-fed hoppers, conveniently placed assembly fixtures and machinery which holds parts in place until they can be assembled, man's skill is substituted for his brawn.

Automation, despite its proved performance and tremendous progress in recent years, is in its infancy. Ford men do not consider themselves qualified to say what its ultimate long-term effects will be on the nation's industry

(continued on page 25)

Roster of Automatic Computing Services

(Information as of August 3, 1954)

The purpose of this Roster is to report organizations (all that are known to us) offering automatic computing services and having at least one automatic computer, either analog or digital. Each Roster entry contains: name of the organization, its address / analog or digital computation provided / notes on equipment / any restrictions as to clients.

We shall be grateful for any additions or corrections that any reader is able to send us.

Some of the abbreviations are as follows:

A	analog
anal	analyzer
CPC	IBM card programmed calculator
D	digital
diff	differential
govtO	available to government agencies or contractors only
unres	unrestricted

ROSTER

Armour Research Foundation of Illinois Inst of Tech, 10 West 35 St, Chicago 16, Ill / A, D / Goodyear Electronic Differential Analyzers, Two Channel Electronic Function Generator, CPC / unres

Askania Regulator Co, 240 East Ontario St, Chicago 11, Ill / A / Philbrick / unres

Battelle Memorial Inst, 505 King Ave, Columbus 1, Ohio / A, D / diff anal, CPC, punch card / unres

Burroughs Corporation Research Center, Paoli, Pa. / D / Burroughs Laboratory Computer / unres

Cornell Computing Center, Rand Hall, Cornell University, Ithaca, N Y / D / CPC, punch card / unres

Engineering Research Associates, Division of Remington Rand, 555 23rd St South, Arlington 2, Va / D / ERA 1101 / unres

General Electric Co, Schenectady, N Y / A / network anal AC and DC, diff anal / unres

The George Washington University, Logistics Research Project, 707 22nd St, Washington, D C / D / ONR automatic relay computer / unres

Financial Publishing Co, Mathematical Tables Div, 82 Brookline Ave, Boston 15, Mass / D / CPC's, punch card / unres

Harvard Computation Laboratory, Harvard University, Cambridge 38, Mass / D / Harvard IBM Mark I, Harvard Mark IV / unres

International Business Machines Corp, 590 Madison Ave, New York, N Y, and elsewhere / D / IBM 701, 650, 604, CPC, punch card, etc / unres

Mass Inst of Technology, Center of Analysis, Cambridge 39, Mass / diff anal, punch card / unres

Moore School of Electrical Engineering, 200 South 33 St, Phila 4, Pa / A, D / diff anal, CPC, punch card / unres

National Bureau of Standards, Applied Mathematics Laboratory, Washington, D C / D / Seac, Dyseac, punch card / govtO

National Bureau of Standards, Institute for Numerical Analysis, 405 Hilgard Ave, Los Angeles 24, Calif / D / Swac, etc / govtO

National Cash Register Company, Electronics Division, (formerly Computer Research Corporation), 3348 West El Segundo Boulevard, Hawthorne, Calif/ D / Cadac 102A, etc / unres

Northrop Aircraft, Inc, Director of Computing, Hawthorne, Calif / A, D / CPC's, Maddida, Binac, punch card, etc / unres

G A Philbrick Researches, Inc, 230 Congress St, Boston 10, Mass / A / Philbrick / unres

Purdue Univ, Dept of Math, Lafayette, Ind / D / CPC, punch card / unres

Raytheon Mfg Co, Computing Services Section, Waltham, Mass / D / automatic electronic digital computer, etc / unres

J B Rea Co, Inc, 1723 Cloverfield Blvd, Santa Monica, Calif / A, D, simulation / Electronic Associates analog computer, Beckman EASE analog computer, CPC / unres

Reeves Instrument Co, 215 East 91 St, New York, N Y / A / Reac / unres

Remington Rand, Inc, 315 4th Ave, New York, N Y / D / Univac, punch card, etc / unres

Rensselaer Polytechnic Institute, Computer Laboratory, Troy, N Y / A / Reeves Electronic Analog Computer, precision magnetic tape recorders for analog computing applications / unres

Scientific Computing Service, Ltd, 23 Bedford Sq, London W C 1, England / D / - / unres

Swedish Board for Computing Machines, Drottningatan 95A, Stockholm, Sweden / D / Bark, Besk / unres

Telecomputing Corp, 133 East Santa Anita Avenue, Burbank, Calif / A, D / IBM punch card, CPC's, automatic graph readers, digital plotters/unres

U S Air Force, Computation Research Sec, Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio / A, D / CPC's, Reac's, punch card / govtO

U S Army, Ballistic Research Laboratories, Aberdeen, Md / D / Ordvac, Edvac, Eniac, Bell Model V, CPC, punch card / govtO

U S Navy, Naval Proving Ground, Dahlgren, Va / D / Harvard Mark II, Harvard Mark III, punch card/ govtO

University Mathematical Laboratory, Free School Lane, Cambridge, England / D / Edsac / unres

University of Michigan, Willow Run Research Center, Ypsilanti, Mich / D / Midac, etc / unres

Univ of Toronto, Computation Centre, Toronto, Ont, Canada / D / Ferranti / unres

Univ of Wisconsin, 306 North Hall, Madison 6, Wisc/ A, D / Philbrick, CPC, punch card / unres

Wayne University, Computation Laboratory, Detroit 1, Mich / A, D / diff anal, Burroughs Unitized Digital Electronic Computer, etc / unres

Westinghouse Electric Corp, Industry Engineering Dept, East Pittsburgh, Pa / A, D / Anacom network anal AC and DC, punch card / unres

- END -

Forum

FORMS OF DATA PROCESSING

From Bill Danch, North Hollywood, Calif.:

"This form of data processing is only until I can brush up on newer equipment from America"

COST OF PROGRAMMING
(continued from page 15)

Less Duplication

Aids to program development and libraries or subroutines have appeared in several places, in fact wherever a computing facility has existed for some time. Although there has been some exchange of library programs between computer groups, an enormous duplication of effort in establishing library routines is going on. The different notations used with each machine discourage reading about the work of other groups. Even where there are duplicate copies of the same commercial machine, as for example the IBM 701 or Remington Rand's UNIVAC, there seems to be no detailed exchange of information between the various installations. Moreover, the fault does not seem to be primarily with the manufacturers, who do provide a central organization for exchange of routines, but with the customers who are all too preoccupied with their pressing commitments to take a long-term view. Wherever there is an electronic computer with a programming staff of ten or more, it is safe to say that a qualified program librarian, whose duty is to collect programs from inside and outside the group and make them generally useful and available, will contribute more in the long run, than any other individual coder.

The establishment of a universal programming notation would be another great help, but this is understandably slow in coming. Until then, it might be useful if there could be set up an arrangement for abstracting programs, that is, for publishing in journals (such as "Mathematical Tables and Other Aids to Computation" or the "Journal of the Association for Computing Machinery") for abstracts in which the ideas of programs are concisely presented in terms which sidestep the difficulties of the special code in which the original program was written.

- END -

DEVELOPMENT OF AUTOMATION
(continued from page 22)

and economy as a whole. They are convinced, however, that anything which elevates man from drudgery -- while giving him better products at the same or lower cost, is fundamentally good. Regarded as an evolutionary development, rather than a revolutionary one, automation, Ford men believe, has started a trend which will continue and will expand as its benefits become known.

- END -

RECIPROCALS
(continued from page 16)

which converges at each end of the range in at most 5 steps. This agrees with the results of solving either:

$$2^{(2^n - 1)} (2/3 - \tfrac{1}{2})^{2^n} < 2^{-31}$$

or

$$(1 - 2/3)^{2^n} < 2^{-31}$$

both of which give values of n which lie between 4 and 5.

Chart 1

Successive Approximations to 1/1

Binary Point
↓

01110001	11000111	00011100	01110010
01111110	01101011	01110100	11110010
01111111	11111011	00000001	01110011
01111111	11111111	11111111	11001101
10000000	00000000	00000000	00000000

Successive Approximations to 1/2

Binary Point
↓

00111000	11100011	10001110	00111010
00111111	00110101	10111010	01111000
00111111	11111101	10000000	10111000
00111111	11111111	11111111	11100111
01000000	00000000	00000000	00000000

- END -

ROSTER OF MAGAZINES
(continued from page 17)

annual subscription rate, about $15 (includes dues) / est. 2500 / no advertising except brief institutional listings on two pages.

Scientific American / monthly / Scientific American, Inc., 2 West 45 St., New York 36, N.Y./ emphasis: ideas and developments in all phases of science, reported for educated men in other specialties / directed to technical management; paid-for; annual subscription $5.00/ about 120,000 / contains advertising.

Occasional articles on computers and automation. The September 1952 issue was devoted to "Automatic Control".

- END -

Forum

ILLUSTRATIONS OF COMPUTER POWERS

From the Willow Run Research Center, University of Michigan, Ypsilanti, Mich.:

For those who attended the meeting of the Association for Computing Machinery in Ann Arbor in June, a demonstrated tour was arranged of the computing facilities at Willow Run Research Center. Here there are three separate large computing facilities, representing three distinct fields of digital and analog computation:

1. MIDSAC: an extremely fast large-scale digital computer designed for the special purpose of real-time simulation and for use as a system control element.

2. WRRC Analog Computer installation: one of the larger such installations in the country.

3. MIDAC: a large-scale, general-purpose digital computer, with a more versatile set of operations and a more general range of capabilities than the MIDSAC.

Midsac

The MIDSAC (Michigan Digital Special Automatic Computer) is a high-speed electronic digital computer designed to control the behavior of a number of systems or objects in real time.

To illustrate the capabilities of the computer, an unclassified demonstration was prepared which simulates the game of pocket billiards. The pool table and the 16 balls are displayed on a 13-inch cathode ray tube. To play the game the player orients a cue, which appears on the tube, just as he would a real cue, and presses a button which transfers control to the computer. The computer then causes the cue ball to proceed in the direction indicated by the cue. In addition, the computer continually computes and displays the position and velocity of each ball, including the modifications due to slow-down and to reflection from any cushion it hits, removes it from the table if it enters a pocket, and, in the case of an impact between two balls, computes new velocity components for both balls and then dispatches them on their new paths. When a shot is completed, there is provision for replacing any ball that may have been scratched, for spotting the cue ball, for re-orienting the cue for the next shot, and, if the game is over, for racking all the balls to start the next game.

In order to perform all the functions required for the game the computer must do approximately 14,000 distinct arithmetic operations per second. (Additions require 40 microseconds and multiplications 88 microseconds on MIDSAC).

The Analog Installation

The Willow Run Research Center's Analog Computing Facility ranks among the larger of such installations in the country. It contains a total of 364 operational amplifiers, 18 servo multipliers, 25 servo resolvers, 12 plotting tables, and 18 channels of oscillographic recording equipment, which may be interconnected in larger or smaller combinations, depending upon the problem.

For the demonstration, part of the computer was converted to simulate the dynamic behavior of an army tank riding over a bump. The computer solves the dynamic equations of motion for the tank and usually presents their solution on a six-channel Brush Recorder. However, the computer may be instructed to move an image on the screen of a dual beam oscilloscope, thus giving a direct presentation of the motion of the simulated tank. The motions of all six road wheels, and the motion of the hull in pitch and bounce, are all accurately portrayed.

A second demonstration set-up combines the outputs of two electronic function generators (photoformers) to produce handwriting on a plotting table.

Midac

MIDAC (Michigan Digital Automatic Computer) is a relatively fast general-purpose electronic digital computer. It employs serial type internal logic, operating at a repetition rate of one megacycle. All logical elements in the central computer are built from standard MIDAC packages, similar to those developed by the National Bureau of Standards for use in the DYSEAC. The internal memory of the computer consists of 64 mercury delay lines, capable of storing eight 45-bit words each, giving a total storage capacity of 512 words. A magnetic drum capable of storing 6,144 words is available as an auxiliary memory. High-speed Ferranti photo-electric readers serve as input.

Since MIDAC is a general-purpose computer several different problems may be presented to illustrate its versatility. MIDAC will "fade" the house in a simulated game of "craps". Rolling the dice and remembering its point, it continues to roll and print the dice until it determines the winner.

(continued on page 28)

FORUM
(continued from page 26)

MIDAC also takes on all comers in "tick-tack-toe". In this game it accepts an opponent's move and immediately replies by printing out the current state of the board including the opponent's latest move and MIDAC's own reply.

In a more serious vein MIDAC solves the damped spring differential equation $m\ddot{x} + c\dot{x} + kx = 0$. The solution is presented in a printed analog of the damped sinusoidal solution function.

A 10 by 10 matrix is solved with the Gauss-Seidel iteration technique in 20 seconds computation time to indicate an example of problems in linear systems.

As an example of a class of more theoretical problems, MIDAC accepts arbitrary integers typed into its memory and immediately prints out all the prime factors.

The MIDAC demonstration is so arranged as to run almost completely automatically from start to finish. Certain human responses and the indication of the termination of the games are necessary, however.

- END -

ROSTER OF ORGANIZATIONS
(continued from page 13)

Underwood Corp., One Park Ave., New York 16, N.Y. / Lexington 2-7000 / ; General Research Lab., 56 Arbor St., Hartford 6, Conn.; and elsewhere/ *C

Accounting machines, adding machines, typewriters. Elliott-Fisher and Sundstrand machines. Underwood Samas Punched Card Accounting Machines and Systems. Underwood electric typewriters, used in Harvard Mark II calculator. ELECOM electronic computers. SEE Electronic Computer Division of Underwood Corporation. Ls (company 10,000; laboratory, 100) Le (1895) DIc RMSa

Vaucanson, 11 rue de Surmelin, Paris 20e, France

Calculating machines. Dc RMSa

The George Washington Univ., Logistics Research Project, 707 22nd St., Washington 7, D. C. / Sterling 3-4539 / *C

ONR relay computer with magnetic drum memory. Data-handling machines. ONR electronic digital computer with magnetic drum memory. Ms (50) Se (1950) Dc RCPa

Wayne University, Cass Ave., Detroit 1, Michigan / Temple 1-1450 / *C

Computation laboratory. 5300-word magnetic drum computer built of Burroughs pulse control equipment. Has Mass. Inst. of Technology Differential Analyzer No. 1. Acquiring digital differential analyzer and electronic analog equipment. Instruction and training. Ss (30) Se (1950) DAc Ra

Wharf Engineering Co., The Wharf, Fenny Compton, Warwickshire, England

Magnetic drums, etc. Ss Se Ic RMSa

- END -

PATENTS

Hans Schroeder
Milwaukee, Wisconsin

The following is a compilation of patents pertaining to computers and associated equipment from the Official Gazette of the United States Patent Office, dates of issue as indicated. Each entry consists of: patent number/ inventor(s) / assignee / invention.

May 18, 1954: 2,678,772 / L W Imm, Pacoima, Calif / Librascope, Inc, Burbank, Calif / Planimeter type mechanical integrator
2,678,965 / G F Ziffer, Cambridge, N B Saunders, Weston, Mass / American Machine and Fdry Co / Magnetic memory

May 25, 1954: 2,679,356 / G M Briers, Peterborough, England / one half to L V Granger/ Digital computer
2,679,366 / P A Noxon, Tenafly, N J / Bendix Aviation Corp, Teterboro, N J / Aircraft control servo system
2,679,587 / K H Perkins, Lancaster, Ohio /U S Sec'y of the Navy / Circuit for producing output voltage proportional to the ratio of two parameters
2,679,620 / T M Berry, Schenectady, N Y / Gen Elec Co / Electrical tracer for guiding a machine
2,679,622 / H B Deri, Rye, N Y / Gen Precision Lab Inc / Curve follower
2,679,636 / C Hillyer, Short Hills, N J / - / Apparatus for comparing information
2,679,638 / L S Bensky and A D Beard, Haddonfield, N J / Radio Corp of America/ Computer system
2,679,639 / H Locher, Uster, Switzerland / Zellweger A G, Apparate und Maschinenfabriken, Uster, Switzerland / Apparatus for determining the mean deviation of a variable magnitude from its average value

June 1, 1954: 2,679,975 / J Grosvalet, Anbony, and J Simon-Suisse, Douala, France / Office National d'Etudes et de Recherches Aeronautiques, Paris, France / Binary multiplier for multiplying a matrix by a column matrix
2,679,976 / E Granat, Paris, France / - /Electric resolver for vectors
2,679,977 / E G Andrews, Baldwin, N Y / Bell Tel Labs, Inc, New York, N Y / Circuit for controlling the algebraic sign in a calculator
2,679,978 / K Kandiah, Strand, Longon,England/ Natl Research Development Corp, London, Eng/ Pulse scaler using multi-electrode tubes
2,680,239 / H L Daniels, St Paul, and J W Hogan, Minneapolis, Minn / Engineering Research Associates, Inc, St Paul, Minn / Apparatus for locating data on the recording medium

June 8, 1954: 2,680,828 / A A Varela, Washington, D C / - / Positioning system using synchros
2,680,838 / A Harnisch, Stuttgart, Germany / Robert Bosch, GmbH, Stuttgart, Germany / Apparatus for integrating time-varying magnitude

June 15, 1954: 2,681,181 / R E Spencer, West Ealing, London, England / Electric and Musical Industries, Ltd, Hayes, Eng /Means for transferring information between magnetic storage cells
2,681,424 / R C Hergenrother, West Newton, Mass / Raytheon Mfg Co, Newton, Mass / Cathode-ray type storage circuit and control
2,681,425 / A V Haeff, Washington, D C / - / Signal integrating tube

June 22, 1954: 2,681,764 / R J Gale, Belmar, N J / U S, Sec'y of the Army / Hyperbolic analog computer for radio navigation
2,682,015 / M A Townsend, Berkeley Hts,N J / Bell Tel Labs, Inc, New York, N Y / Gaseous stepping tube
2,682,043 / C J Fitch, Endicott, N Y / Int'l Business Mach Corp, New York, N Y / Character sensing device using a plurality of photoelectric devices

June 29, 1954: 2,682,389 / C H Doersam, Jr, Port Washington, N Y / - / Digital device for generating the cartesian coordinates of a vehicle
2,682,615 / G C Sziklai and K H Powers, Princeton, N J / Radio Corp of Amer / Switching and gating circuit using saturable reactors

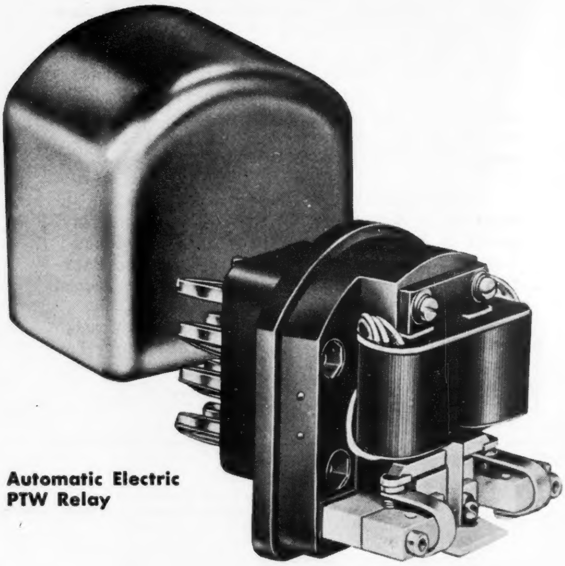
July 6, 1954: 2,683,003 / R J Kutzler, St Louis Park, and H D Eckhardt, Minneapolis, Minn / Minneapolis Honeywell Regulator Co, Minneapolis, Minn / Automatic pilot servo mechanism

July 13, 1954: 2,683,819 / T J Rey, Hayes, England / Electrical and Musical Industries, Ltd, Hayes, Eng / Storage device using magnetizable rings
2,683,843 / W A Geyger, Tacoma Park, Md /U S, Sec'y of the Navy / Servo system for controlling a two-phase motor, using DC damping
2,683,845 / W A Geyger, Tacoma Park, Md / U S, Sec'y of the Navy / Damping method for motor control system

- END -

New polar relay...

sensitive, rugged, compact!



Automatic Electric
PTW Relay

Here's a new polar relay that will soon be setting records for long service life! Its sensitivity gives peak performance for high-speed polarized pulse repeating, or for applications where low current is transmitted over long lines. The Series PTW Relay is also recommended for line-current direction indication or as a differential relay in the "Wheatstone Bridge" type of control. Advanced features include:

simplified design and long service life

New design eliminates many parts and adjustments formerly required. Relay gives *billions* of operations without re-adjustment.

extreme sensitivity

Unit operates on currents as low as 2 to 12 milliamperes, depending upon number and combination of windings used. Signals as low as 10 milliwatts through the two line-windings will "trigger" the relay.

reduced bounce and wear

A new method of armature support limits longitudinal movement. There are no bearings to wear . . . the usual rocking motion in contact make-and-break is reduced. Armature bounce is virtually eliminated; contacts last longer.

improved characteristics in smaller size

Because of increased magnetic efficiency, the coils take less space and need fewer turns. The lower coil impedance of this compact unit gives improved characteristics.

fast response

Travel time is as low as .9 milliseconds, depending upon contact gap and windings used.

send for circular

For a small, fast, sensitive polar relay that out-performs and outlasts all others, specify this new Automatic Electric Series PTW Relay. For details ask for Circular 1821. Write: Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Ill. In Canada: Automatic Electric (Canada) Ltd., Toronto. Offices in principal cities.

helpful technical data

Make and Break—75% total "make" on both contacts at 60 cycles per second with .006" contact gap and 23 milliamperes of sine wave ac. Simple, easy re-adjustment can be made in the field.

Windings—Four windings: two line-windings, each 139 ohms resistance and only .5 henry inductance; other two windings, each 101 ohms and .125 henry. The number of coil turns to be placed in series aiding can vary from 1400 to 8400.

Cover—Snap-on cover easily removed for inspection and adjustment of relay.

Mounting—Jack mountings, available for flush or surface mounting.

Size—2¼" wide, 2½" deep and 2$^{11}/_{16}$" high (plus ⅝" projection of banana plugs).

For more detailed information, ask for Circular 1821.

RELAYS PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF **SWITCHES**

AUTOMATIC ELECTRIC

CHICAGO

PROEBSTING, TAYLOR INC.
Automatic Electric
Ad No. RE-40

Forum

TRAINING PERSONNEL FOR COMPUTERS

From: Arvid W. Jacobson, Director, Computation Laboratory, Wayne University, Detroit 1, Michigan

The first conference dealing with Educational and Manpower Problems in the Computing Machinery Field was held at Wayne University on June 22 and June 23, 1954. Over 40 papers were given, with very active audience participation in the discussions. The interest and enthusiasm displayed were high.

Four main areas were included in the conference discussions. The first area was manpower required by business, industry, computer manufacturers, and government agencies. The facts presented in these discussions were the results, in many cases, of extensive study and collected questionnaires. Perhaps for the first time some idea of the magnitude of manpower problems at different levels of competence was obtained.

The second area of interest was educational programs. The training and research problem was discussed from the standpoint of both undergraduate and graduate collegiate courses, and industrial and government training courses. The general conviction was that institutions of higher learning should bear the brunt of the training and research reqquired; many significant recommendations were offered relative to these educational efforts.

The third area was the influence of automatic computers on technical and general education. A number of papers with excellent content and insight were offered during these discussions. How basic concepts and skills associated with the computing machine field should be introduced in high schools and colleges, was carefully discussed. The relationship of special computer courses to existing training in basic sciences received much attention. Substantial agreement was revealed in favor of education in the fundamental sciences.

The fourth area was cooperation by educational institutes, industry, and governmental agencies. The papers described numerous ways in which this cooperation now takes place. The Computation Laboratory was cited as an excellent example of joint effort by both industrial and educational interests towards establishing a training and computing facility of broad scope. Again the general conviction of the conference was to emphasize teamwork among schools, industry, and government.

Although the conferees represented a diverse group, the conference clarified many problems dealing with educational practices and policies, and with technical and scientific manpower needs. A fairly complete record of the papers and discussions given at the conference will be published as proceedings, available from the Computation Laboratory, for $5.00.

* * *

REPLY FORMS: Who's Who Entry; Reader's Inquiry

Paste label on envelope:↓

BUSINESS REPLY LABEL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

4¢ Postage Will Be Paid By —

EDMUND C. BERKELEY AND ASSOCIATES

36 West 11th Street

New York 11, N. Y.

FIRST CLASS

PERMIT NO 1680

Sec. 34.9, P. L. & R.

NEW YORK, N. Y.

Enclose form in evelope:↓

IDENTIFICATION

Name (please print).................................

Address.................................

Organization (& address)?.................................

Title?.................................

Please fill in completely

WHO'S WHO ENTRY FORM

Year of Birth?..................

MAIN INTERESTS:

( ) Design
( ) Construction
( ) Applications
( ) Sales
( ) Electronics
( ) Mathematics
( ) Business
( ) Programming
( ) Other (specify):

College or last school?.................................

Year of entering the computing machinery field?.................................

Occupation?................................. (Enclose more information about yourself if you wish — it will help in your listing.)

READER'S INQUIRY FORM

Please send me additional information on the following subjects for which I have circled the CA number:

1	2	3	4	5	26	27	28	29	30	51	52	53	54	55	76	77	78	79	80	101	102	103	104	105	126	127	128	129	130
6	7	8	9	10	31	32	33	34	35	56	57	58	59	60	81	82	83	84	85	106	107	108	109	110	131	132	133	134	135
11	12	13	14	15	36	37	38	39	40	61	62	63	64	65	86	87	88	89	90	111	112	113	114	115	136	137	138	139	140
16	17	18	19	20	41	42	43	44	45	66	67	68	69	70	91	92	93	94	95	116	117	118	119	120	141	142	143	144	145
21	22	23	24	25	46	47	48	49	50	71	72	73	74	75	96	97	98	99	100	121	122	123	124	125	146	147	148	149	150

PUBLICATIONS: COMPUTERS, ROBOTS, SYMBOLIC LOGIC, ETC.

BRIEF — FILLED WITH INFORMATION — CLEAR — SCIENTIFIC

P 22: TIC-TAC-TOE PLAYING MACHINE PLANS. Report Plans, circuits, parts list, etc., for constructing an automatic machine which will play the game of ordinary tic-tac-toe with a human being, on a board with nine squares. Second edition, following construction.....$4.00

P 10: THE CONSTRUCTION OF LIVING ROBOTS. Report. Discusses the properties of robots and of living beings. Outlines how to construct robots made out of hardware which will have the essential properties of living beings. Gives circuit diagrams.................................$1.00

P 6: CONSTRUCTING ELECTRIC BRAINS. Reprint of the series of thirteen articles by E. C. Berkeley and Robert A. Jensen published in "Radio Electronics", Oct. 1950 to Oct. 1951. Explains simply how an automatic computer is constructed; how to make it add, subtract, multiply, divide, and solve problems automatically, using relays or electronic tubes or other devices. Contains many examples of circuits..................... $2.20

P 13: A SYMBOLIC ANALYSIS OF RELAY AND SWITCHING CIRCUITS. Reprint of the classic paper by Claude E. Shannon, mathematician and scientist, published 1938 in the Transactions of the AIEE, and long out of print. The first application of Boolean algebra to relays and other on-off circuit elements...........................$0.60

Edmund C. Berkeley and Associates
815 Washington St., R9 , Newtonville 60, Mass.

Please send me publications circled
P6 P10 P13 P22
and ( ) your announcement of courses offered by mail. Returnable in seven days for full refund if not satisfactory. I enclose $_______ in full payment. (Add 10¢ per item to cover cost of handling and mailing.)

My name and address are attached.

COMPUTERS AND AUTOMATION - Back Copies & Reprints

ARTICLES: January, 1953: Brains: Electronic and Otherwise -- A. S. Householder
What Computers Do -- S. B. Williams
The Parameters of a Business Problem in Reading -- C. H. Dent
Automatic Computers on Election Night -- E. F. Murphy and E. C. Berkeley
March: Gypsy, Model VI, Claude Shannon, Nimwit, and the Mouse -- George A. W. Boehm,
Water and Computers -- Henry M. Paynter, Jr., Mass. Inst. of Technology, and Neil Macdonald
The Concept of Automation -- E. C. Berkeley
The ERA 1103 Automatic Computer -- Neil Macdonald
April: The Art of Solving Secret Ciphers, and the Digital Computer -- Fletcher Pratt
Avenues for Future Development in Computing Machinery -- Edmund C. Berkeley
Hungarian Prelude to Automation -- Gene J. Hegedus
May: Compiling Routines -- Grace M. Hopper, Remington Rand
Mechanical Translation -- Andrew D. Booth, Birkbeck College, London
Medical Diagnosis -- Marshall Stone, University of Chicago
July: Machine Translation -- Y. Bar-Hillel, Mass. Inst. of Technology
Robot Traffic Policemen -- George A. W. Boehm,
How to Talk About Computers -- Rudolf Flesch, Author of "Art of Plain Talk"
September: The Soviet Union: Automatic Digital Computer Research -- Tommaso Fortuna
Digital Computer Questionnaire -- Lawrence Wainwright
"How to Talk About Computers": Discussion -- G. G. Hawley and others
October: Computers in the Factory -- David W. Brown
The Flood of Automatic Computers -- Neil Macdonald
The Meeting of the Association for Computing Machinery in Cambridge, Mass., September, 1953 -- E. C. Berkeley
November: Who Will Man the New Digital Computers? -- John W. Carr III
Electronic Equipment Applied to Periodic Billing -- E. F. Cooley
Air-Floating: A New Principle in Magnetic Recording of Information -- Glenn E. Hagen
December: How a Central Computing Laboratory Can Help Industry -- Richard F. Clippinger
"Combined" Operations in a Life Insurance Company Instead of "Fractured" Operations -- R. T. Wiseman
"Can Machines Think?": Discussion -- J.L. Rogers and A. S. Householder
January, 1954: The End of an Epoch: The Joint Computer Conference, Washington, D. C., December, 1953 -- Alston S. Householder
Savings and Mortgage Division, American Bankers Association: Report of the Committee on Electronics, September, 1953 -- Joseph E. Perry and others
Automation in the Kitchen -- Fletcher Pratt
February: Language Translation by Machine: A Report of the First Successful Trial -- Neil Macdonald
Reflective Thinking in Machines -- Elliot L. Gruenberg
Glossary of Terms in Computers and Automation: Discussion -- Alston S. Householder and E.C. Berkeley
March: Towards More Automation in Petroleum Industries -- Sybil M. Rock
Introducing Computers to Beginners -- Geoffrey Ashe
Subroutines: Prefabricated Blocks for Building -- Margaret H. Harper
Glossaries of Terms: More Discussion -- Nathaniel Rochester, Willis H. Ware, Grace M. Hopper and others
April: Processing Information Using a Common Machine Language: The American Management Association Conference, February, 1954 -- Neil Macdonald
The Concept of Thinking -- Elliot L. Gruenberg
General Purpose Robots -- Lawrence M. Clark
May: Ferrite Memory Devices -- Ephraim Gelbard and William Olander
Flight Simulators -- Alfred Pfanstiehl
Autonomy and Self Repair for Computers -- Elliot L. Gruenberg
A Glossary of Computer Terminology -- Grace M. Hopper
July: Human Factors in the Design of Electronic Computers -- John Bridgewater
What is a Computer? -- Neil Macdonald

REFERENCE INFORMATION (in various issues):

Roster of Organizations in the Field of Computers and Automation / Roster of Automatic Computing Services / Roster of Organizations Making Components / List of Automatic Computers / Who's Who in the Field of Computers and Automation / Automation -- List of Outstanding Examples / Books and Other Publications / Glossary / Patents

Price of back copies, if available, $1.25 each.

A subscription (see rates on page 4) may be specified to begin with any issue from July, 1954, to date.

REPRINTS: Index No. 1 (from December, 1953, issue) -- 20 cents
Glossary of Terms in the Field of Computers and Automation (from three 1953 issues) -- 60 cents

WRITE TO:

Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles and reference information related to computing machinery, robots, automatic controllers, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $4.50 a year in the United States. Single copies are $1.25. The magazine was published monthly except June and August between March, 1953, and September, 1954; prior to March 1953 it was called "The Computing Machinery Field" and published less often than ten times a year.

2. What is the circulation? The circulation includes 1200 subscribers (as of Aug. 3); over 300 purchasers of individual back copies; and an estimated 1500 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are some 3500 or 4000 people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the July issue was 1800 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale. A mailing to some 2000 nonsubscribers in December, 1953 (with 173 responses up to March, 1954) indicated that two-thirds of them saw the magazine (library, circulation, or friend's copy) and of these two-thirds over 93% "liked it".

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7"x10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of full pages (ad size 7" by 10", basic rate, $130) and half pages (basic rate, $70); back cover, $250; inside front or back cover, $160. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $220; four-page printed insert (two sheets), $400. Classified advertising is sold by the word (40 cents a word) with a minimum of ten words. We reserve the right not to accept advertising that does not meet our standards.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

The Austin Co.
Automatic Electric Co.
Burroughs Corporation
Computing Devices of Canada, Limited
Consolidated Engineering Corp.
Electronic Associates, Inc.
Federal Telephone and Radio Co.
Ferranti Electric Co.
Ferroxcube Corp. of America
General Ceramics Corp.
Hughes Research and Development Lab.
Intelligent Machines Research Corp.
International Business Machines Corp.
Ketay Manufacturing Co.
Laboratory for Electronics
Logistics Research, Inc.
The Macmillan Co.
Monrobot Corp.
George A. Philbrick Researches, Inc.
Potter Instrument Co.
Raytheon Mfg. Co.
Reeves Instrument Co.
Remington Rand, Inc.
Sprague Electric Co.
Sprague Electric Products, Inc.
Telecomputing Corp.
VISIrecord, Inc.

ADVERTISING INDEX - SEPTEMBER, 1954

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions, such as, What are your products? What are your services? And for each product, What is it called? What does it do? How well does it work? What are its main specifications? We reserve the right not to accept advertising that does not meet our standards.

Following is the index to advertisements:

If you wish more information about any of the products or services mentioned in one or more of these advertisements, you may circle the appropriate CA No.'s on the Reader's Inquiry Form (see page 32) and send that form to us (we pay postage; see the instructions). We shall then forward your inquiries, and you will hear from the advertisers direct.

e.
wers
pro-
in
our

Page

or
s
t-